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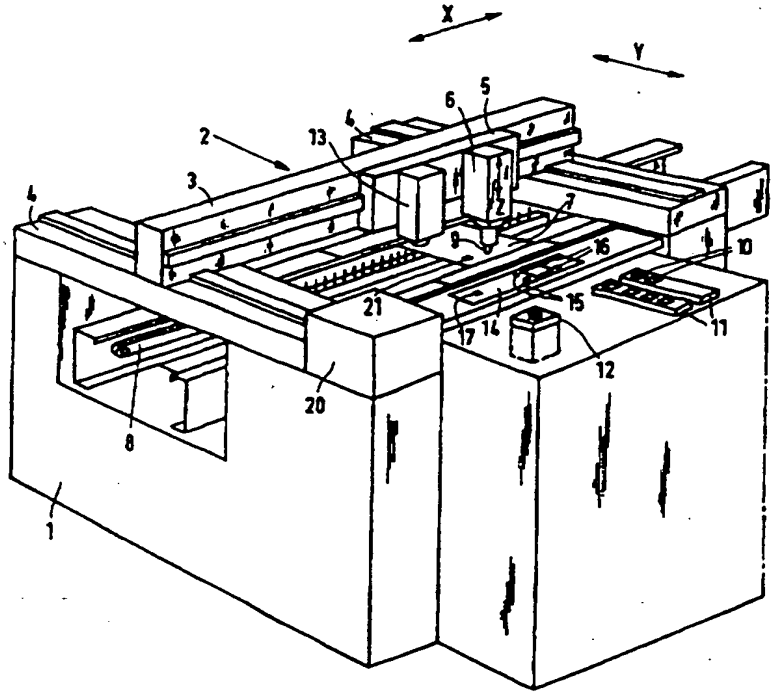
(54) Title: METHOD OF PLACING A COMPONENT ON A SUBSTRATE AND COMPONENT PLACEMENT MACHINE FO CARRYING OUT THE METHOD

(57) Abstract

The invention relates to a method of and a component placement machine for placing a component (10) onto a substrate (7), in which, after a component has been picked up by a placement head (6) secured to an arm (5) of a robot (2), the component is moved into an image field (18) of a stationary first imaging device (12) and the component is imaged, after which a second imaging device (13), which is also secured to said arm (5) of the robot, images a mark (21) of the substrate (7), subsequently the positions of the component and the position where the component is to be placed onto the substrate are calculated from the resulting image data, and finally the placement head places the component onto the substrate at the desired position. During imaging of the component (10), in order to compensate for inaccuracies in the distance between the placement head and the second imaging device, the first imaging device (12) also images at least one mark (16) situated on a reference plate (14) and at the same time the second imaging device (13) images a second mark (17) on the reference plate, after which the position of the component (10) relative to the second imaging device (13) is calculated from the resulting image data.



Method of placing a component on a substrate and component placement machine for carrying out the method.

The invention relates to a method of placing a component onto a substrate, in which, after a component has been picked up by a placement head secured to an arm of a robot, the component is moved into an image field of a stationary first imaging device and the component is imaged, a second imaging device, which is also secured to said arm of the robot, images a mark of the substrate, after which the position of the component and the position where the component is to be placed onto the substrate are calculated from the resulting image data and the placement head subsequently places the component onto the substrate at the desired position.

Such a method is known from US-A-5,084,959. In this known method the position of the component relative to the second imaging device is calculated after an image of the component has been made by means of the first imaging device. This is possible since a reference point of the placement head is always moved to a fixed position in the image field of the first imaging device and the distance between the reference point of the placement head and a reference point of the second imaging device is known. However, in practice this distance is not always found to be constant, which gives rise to an inaccuracy in the placement of the component on the substrate. The fact that this distance is not constant is caused in particular by temperature differences. However, other influences, such as undesired vibrations, may also give rise to erroneous measurements.

It is an object of the invention to place a component at the desired position on a substrate with a high accuracy.

To this end, the invention is characterized in that during imaging of the component the first imaging device also images at least one mark situated on a reference plate and at the same time the second imaging device images at least one other mark on the reference plate, after which the position of the component relative to the second imaging device is calculated from the resulting image data.

The advantage of this method is that the position of the component picked up by the placement head relative to the second imaging device can be determined during the placement process of each component on the substrate. The desired position where the component is to be placed on the substrate is determined by means of the second imaging device. By means of the data of these two positions the robot can direct the placement head with the component exactly to the desired position in order to place the component.

Preferably, for imaging the component the component is positioned at substantially the same image distance as the first mark.

The invention also relates to a component placement machine comprising a frame, a robot, a transport system for the transport of substrates, a placement head for placing components onto the substrate, which placement head is secured to an arm of the robot, a first imaging device, which is fixedly connected to the frame, for determining the position of the component, and a second imaging device, which moves along with the placement head, for detecting a mark of the substrate.
In order to place a component at the desired position on the substrate with a higher accuracy, the placement machine is characterized in that the placement machine comprises a reference plate having at least a first mark and a second mark, which marks are situated at a fixed distance from one another and which first mark is situated within the image field of the first imaging device during imaging of the component, while at the same time the second mark is situated within the image field of the second imaging device. The marks on the reference plate have been applied with a very high accuracy. Their exact position relative to one another is stored in an image processor, which calculates the instantaneous position of the component with the aid of the image data.

Preferably, the reference plate has an opening which allows a component picked up by the placement head to pass through and the reference plate has at least one first mark adjacent the opening. This enables the component to be positioned in the opening in such a manner that the component, particularly contact faces or pins thereof, are disposed in the same image plane of the imaging device as that in which the mark of the reference plate is situated.

Moreover, the reference plate is preferably disposed at substantially the same level as the substrate. This raises the imaging accuracy and hence the placement accuracy of the component.

The invention will now be described in more detail with reference to an exemplary embodiment shown in the drawings, in which

Fig. 1 shows a component placement machine for carrying out the method,

Fig. 2 is a plan view showing a reference plate and a substrate, and

Fig. 3 is a side view of the placement head and the imaging devices in a position for imaging.

The component placement machine in Fig. 1 comprises a machine frame 1 carrying an X-Y robot 2. The robot is formed by a slide 3, which is movable in the Y-direction over two parallel guide members 4 of the frame and which is movable along the slide 3 in the X direction by means of an arm 5. The arm carries a component placement head 6. The machine has a transport mechanism for the transport of substrates, for example printed circuit boards, through the machine. Of this transport mechanism only the conveyor belt 8 is shown. The component placement head 6 comprises a suction nozzle 9 by means of which components 10 are picked up from a component feeder 11, which are subsequently placed onto the substrate 7. The suction nozzle can be driven in a Z direction and a ϕ direction. In the ϕ direction means that the nozzle can perform an angular rotation ϕ about its longitudinal axis. In order to place the components very accurately at the desired position on a substrate, the machine comprises a first imaging device 12, which is fixedly secured to the frame, and a second imaging device 13, which is secured to the arm 4 of the robot, adjacent the placement head. The machine further comprises a reference plate 14. The reference plate has an opening 15. This opening is so large that the component can pass through the opening. Near the opening the reference plate has first marks 16, in then present example four. The reference plate has a second mark 17 at some distance from the opening. The second mark has a very accurate and known position relative to the first marks. The stationary first imaging device 12 is disposed underneath the opening 15 of the reference plate. Both the opening 15 and the first marks 16 surrounding this opening are situated within the image field 18 of the imaging device. The reference plate is preferably made of a transparent material. The method of placing a component onto a substrate will be described hereinafter with reference to Figures 2 and 3.

The robot is first directed to the component feeder 11, where the suction nozzle 9 of the placement head 4 picks up a component 10 with the aid of a partial vacuum.

CLAIMS:

1. A method of placing a component onto a substrate, in which, after a component has been picked up by a placement head secured to an arm of a robot, the component is moved into an image field of a stationary first imaging device and the component is imaged, a second imaging device, which is also secured to said arm of the robot, images a mark of the substrate, after which the position of the component and the position where the component is to be placed onto the substrate are calculated from the resulting image data and the placement head subsequently places the component onto the substrate at the desired position, characterized in that during imaging of the component the first imaging device also images at least one mark situated on a reference plate and at the same time the second imaging device images at least one other mark on the reference plate, after which the position of the component relative to the second imaging device is calculated from the resulting image data.

2. A method of placing a component onto a substrate as claimed in Claim 1, characterized in that for imaging the component the component is positioned at substantially the same image distance as the first mark.

3. A component placement machine comprising a frame, a robot, a transport system for the transport of substrates, a placement head for placing components onto the substrate, which placement head is secured to an arm of the robot, a first imaging device, which is fixedly connected to the frame, for determining the position of the component, and a second imaging device, which moves along with the placement head, for detecting a mark of the substrate, characterized in that the placement machine comprises a reference plate having at least a first mark and a second mark, which marks are situated at a fixed distance from one another and which first mark is situated within the image field of the first imaging device during imaging of the component, while at the same time the second mark is situated within the image field of the second imaging device.

4. A component placement machine as claimed in Claim 2, characterized in that the reference plate has an opening which allows a component picked up by the placement head to pass through and the reference plate has at least one first mark adjacent the opening.

5. A component placement machine as claimed in Claim 3, characterized in that reference plate is disposed at substantially the same level as the substrate.

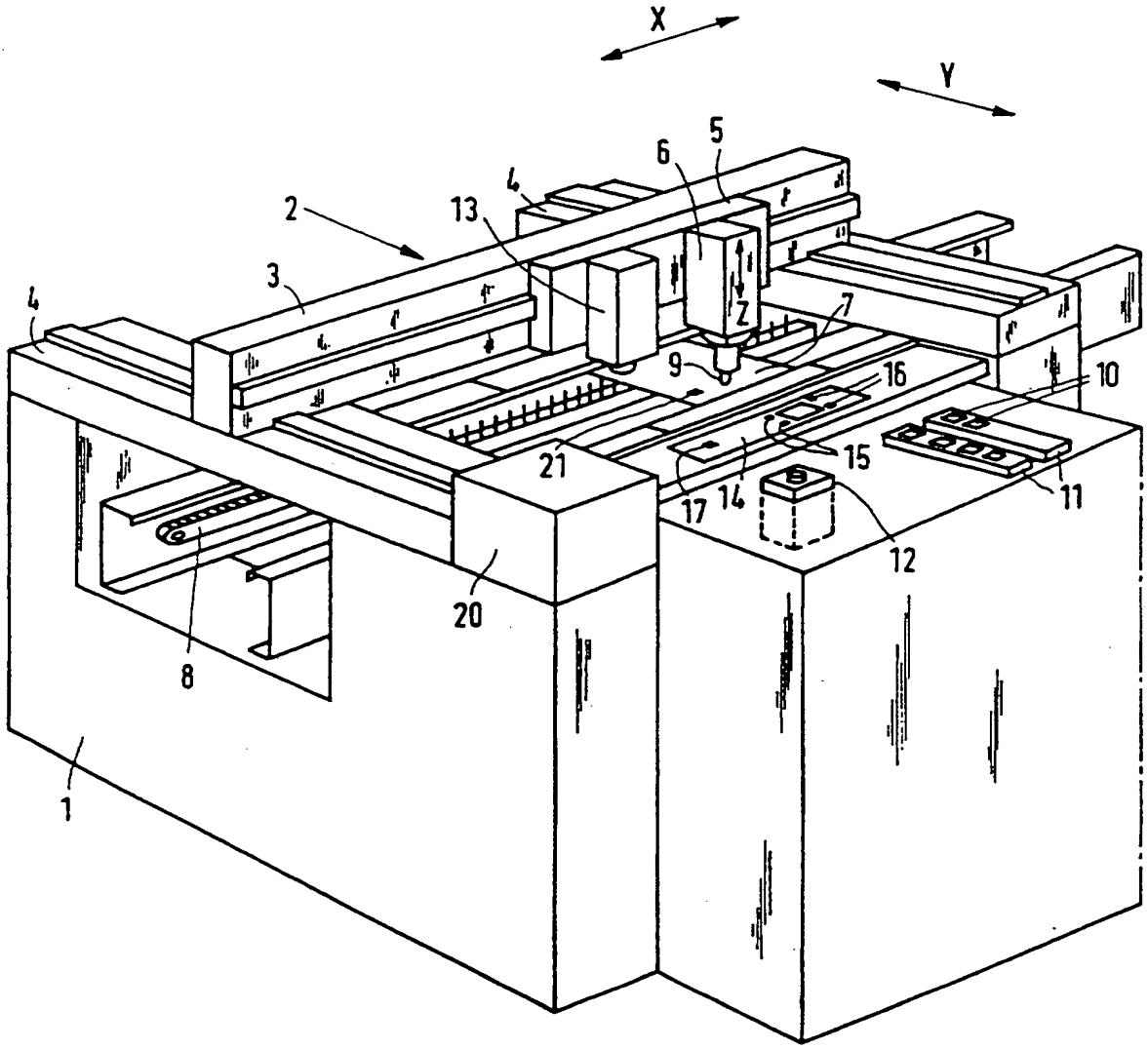


FIG.1

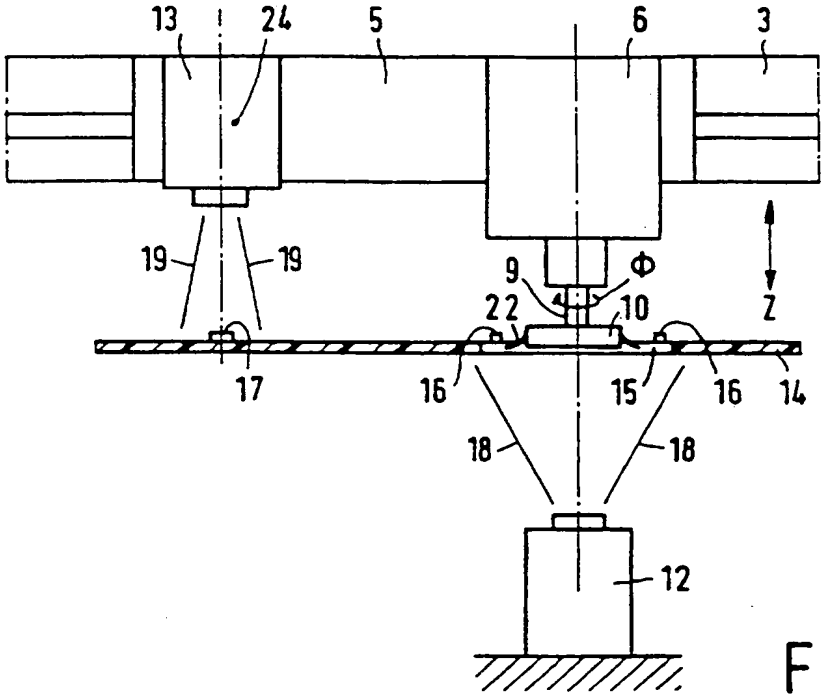

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FIG.2

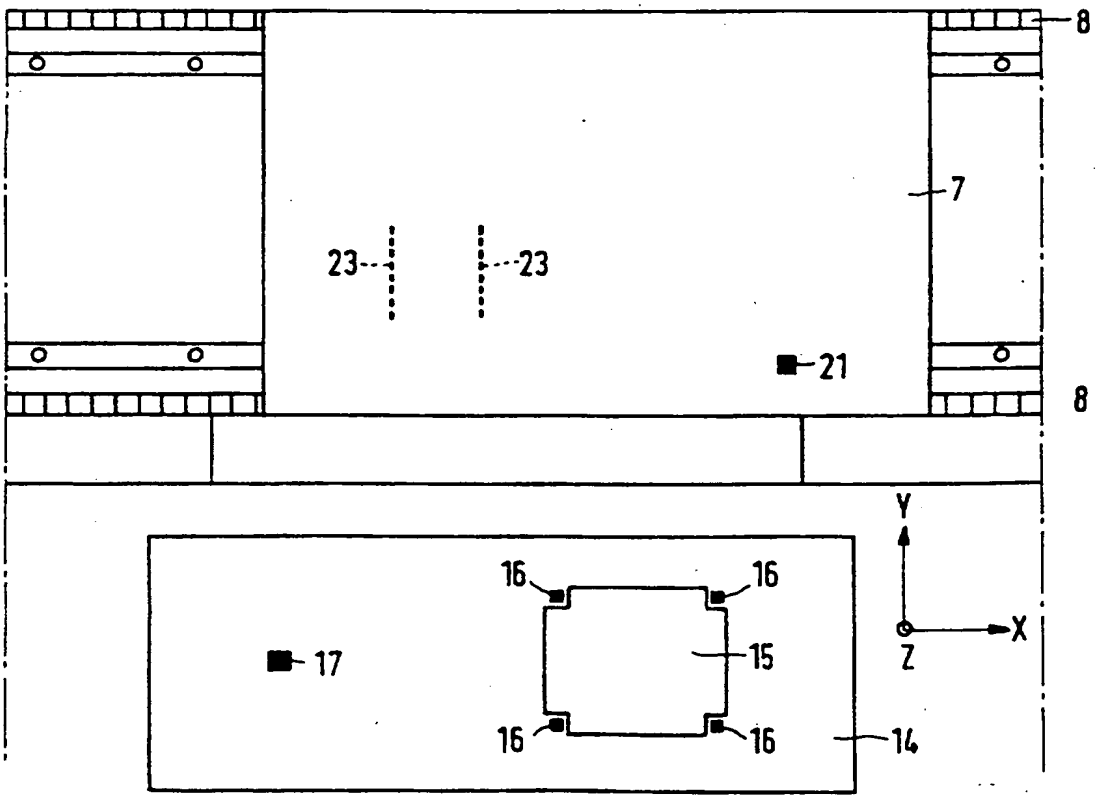
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FIG.3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 97/00167

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H05K 13/04
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H05K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5084959 A (T. ANDO ET AL), 4 February 1992 (04.02.92), figure 1, abstract ---	1,3
Y	US 4980971 A (M.K. BARTSCHAT ET AL), 1 January 1991 (01.01.91), figure 2, abstract ---	1,3
A	US 4738025 A (A.L. ARNOLD), 19 April 1988 (19.04.88), figure 1, abstract --- --------	1-5

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
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Date of the actual completion of the international search	Date of mailing of the international search report
16 Sept 1997	26 -09- 1997
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Vilho Juvonen Telephone No. +46 8 782 25 00